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QUALIFYING PAPER

For the degree of

bachelor
(degree name)

topic: Improvement of the technological process of mechanical processing of hub 180.07.202

Submitted by: fourth year student 4 , group ІМП-42
specialty 131 «Applied Mechanics»

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ABSTRACT

Qualification work of bachelor's degree: "Improvement of the technological process of mechanical processing of hub 180.07.202" of the student of group IMP-42 TNTU named after Ivan Puluj OMOSEBI SHADRACK OREOFE.

Keywords: *technology, cutting modes, workpiece, manufacturability, operation, device, equipment.*

The purpose of the work is to improve the technology of making hub 180.07.202 with the appropriate justification.

To achieve this goal, the following tasks are solved.

The first section analyzes the design features of the hub 180.07.202, its application, technical requirements for surfaces, and its manufacturability.

In the second section, they determined the type of product and ion, chose the best option for making the workpiece – casting in a coquel.

The third section presents the design and principle of operation of the devices for milling the end, for milling the plane, the conductor and for drilling and cutting threads, as well as devices for sending chamfers, their accuracy and power parameters are calculated.

The relevant conclusions and the list of references are presented.

Annexx provides the technological process of manufacturing the hub flange 180.07.202 and the specifications for the graphic part.

CONTENT

ENTRY

In the qualification work of The Bachelor's, the technological process of mechanical processing of the hub 180.07.202 was improved. The part is part of the drive of the mixing system of the grain disinfectant hopper and is designed to accommodate the bearing in it.

In the basic technological process of machining parts of the hub 180.07.202, the following basic parameters are used at the enterprise for small-scale production: universal debilitation devices as technological equipment are used for mechanical processing of parts; universal metal-cutting equipment of normal accuracy is used; the use of universal measuring instruments to control the accuracy and roughness of treated surfaces; the use of universal standard cutting tools for machining blanks; the concentration of operations of the basic technological process corresponded to this type of production.

1 GENERAL TECHNICAL PART

1.1 Service purpose details

The designation of the surfaces of the part is shown in Figure 1.1. Consequently, based on the design purpose, the main surfaces of the body are surfaces *A*, *B*,*C*,D, which are used as a constituent, centering and supporting. *E*,*F*,*G*,*H*,*I*,*J*,*K*,*L*,*M*,*N*,*O* – are auxiliary and are designed for the installation or fixation of auxiliary components, serve as technological bases, form the design of the product.

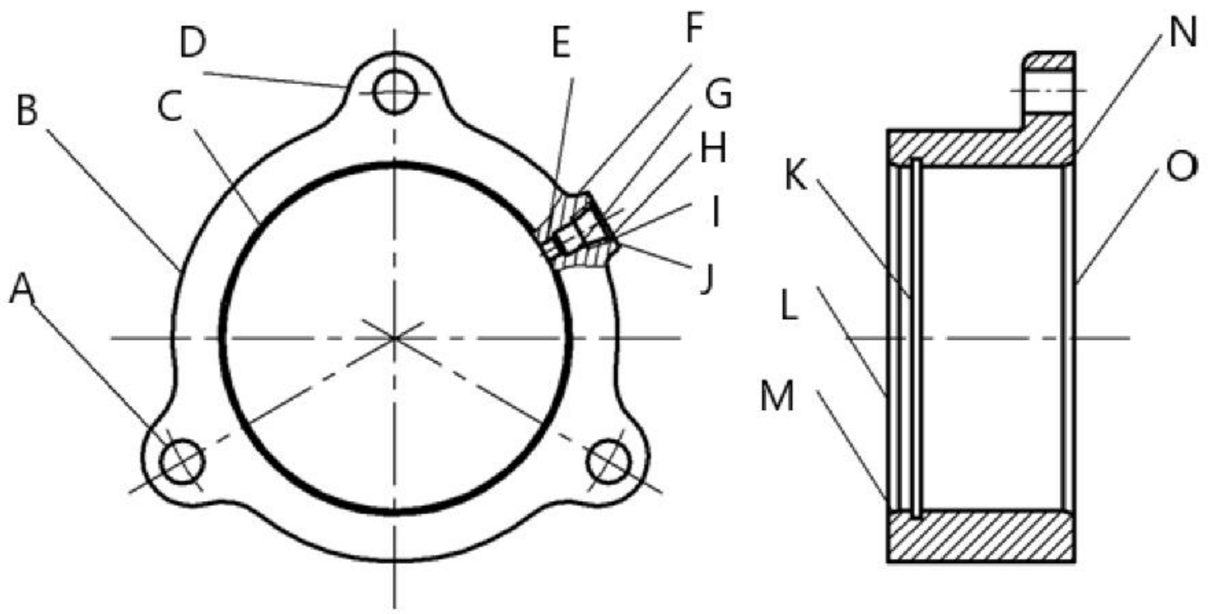


Figure 1.1 – Marking the surfaces of the part

In particular, the surfaces *C, K, M, N* are designed for installation and centering in the housing of the bearing, locking rings and cuffs of the drive shave in the assembly of 0,05 mm the unit. Processed according to the 9th Quality of Accuracy. Holes (surface *A*) are designed for fastening with a screw connection of the bearing cover to the body itself, they are performed on the 12th qualifier with an admission to placement relative to the axis of the body no more than 0,1 mm.

The part is made of cast iron SF20 according to GOST 1412-85. Structural purpose of cast iron SCH20 GOST 1412-85 – housing, clips, rollers, forks, brackets and other parts that work under the influence of small and medium static and dynamic loads. The chemical and mechanical properties of cast iron SF20 are given in tables 1.1 and 1.2 [7].

Table 1.1 – Chemical composition of cast iron SCH20 GOST 1412-85

Brand of material	Content of chemical elements						
	C, %	Mn, %	Si, %	S, %	P, %	Cr, %	Ni, %
				no more			
Cast iron SCH20	3,0÷3,3	0,8÷1,2	1,3÷1,7	0,15	0,3	0,3	0,75

Table 1.2 – Mechanical properties of cast iron SCH20 GOST 1412-85

Brand of material	Characteristic					
	σ_B, MPa	σ_T, MPa	δ_5, %	ψ, %	KCU, J/cm^2	HB
Cast iron SCH20	210	315	40	45	75	170... 240

1.2 Analysis of technical requirements details

Proveemo analysis of the basic technical requirements for surfaces of the part with the establishment of the method and their implementation and control.

Table 1.3 – Analysis of technical conditions

Denomination	Technical condition or requirement	Execution method	Method of control
1	2	3	4
Into	Roughness *Grade* = 1.6 microns;	Finishing sharpening in a 3	Roughness samples,

	surface accuracy according to the 9th qualifier; deviation from roundness no more than 0,05 mm	cam cartridge	template, control device
K, N	Roughness *Rz* = 80 microns; surface accuracy on the 11th qualifier; end beating no more than 0,1 mm	Milling in a special device, finishing sharpening in a 3 cam cartridge	Samples of roughness, template, special control device
And	Ensuring the placement of holes with a deviation for placement from the centering surface *B* is not more than 0,1 mm; surface accuracy on the 12th qualifier	Drilling in a special device	Calibration, placement template

So, analyzing the design of the part, it can be stated that the product has sufficient rigidity for machining with various cutting tools, as well as it can be fixed in various technological devices without disturbing its geometric dimensions and shapes.

Mechanical processing of parts is advisable to carry out in special devices with installation on prisms, as well as the use of self-centered turning cartridges with pneumatic clamping.

1.3 Analysis of the manufacturability of the design of the part

The workpiece of the part is the casting of the III class, obtained by casting into earthen forms. This method of obtaining the workpiece is not difficult, but since the responsible surfaces of the part require machining and the mass of the workpiece is too large, respectively, to improve the accuracy of surfaces and reduce the mass, as a workpiece, you can use casting in sand and clay forms or obtained by casting in a coquel, and this can reduce the total cost of the product by reducing the fate of waste and the cost of machining.

So, analyzing the design of the part, it can be stated that the product has sufficient rigidity for machining with various cutting tools, as well as it can be fixed in various technological devices without disturbing its geometric dimensions and shapes.

The level of manufacturability of the design according to the accuracy of processing is characterized by the accuracy coefficient, which is determined by the following formula [2]

$$K_{T.CH} = 1 - \frac{1}{T_{sr}}, \quad (1.1)$$

where T_{sr} is the average numeric value of the product processing accuracy parameter

$$T_{sr} = \frac{\sum T_{n_i}}{\sum n_i}, \quad (1.2)$$

where T is the numeric value of the processing accuracy parameter (qualifier);
n_i - the number of sizes of the corresponding accuracy class.

$$T_{sr} = \frac{2 \cdot 6 + 7 + 11 \cdot 14}{14} \approx 12.$$

Accordingly, the accuracy coefficient is equal to

$$K_{T.CH} = 1 - \frac{1}{12} = 0,91$$

The level of manufacturability in the roughness of the surface is estimated by the roughness coefficient [2]

$$K_{sh} = 1 - \frac{1}{W_{sr}}, \quad (1.3)$$

where W_{sr} is the average numerical value of the roughness of the surfaces of the product.

$$W_{sr} = \frac{\sum W \cdot n_i}{\sum n_i}, \qquad (1.4)$$

where W is the numeric value of the roughness parameter;

n_i – the number of surfaces with the corresponding numerical value of the roughness parameter.

$$W_{sr} = \frac{2 \cdot 80 + 4 \cdot 1,6 + 0,8 + 3 \cdot 6,3}{10} \approx 18,61.$$

Accordingly, the roughness coefficient

$$K_{sr} = 1 - \frac{1}{18,61} = 0,95.$$

Material usage factor

$$K_{v.m} = \frac{M_d}{M_z}, \qquad (1.5)$$

where M_d is the mass of the part, M_d = ;0,235 kg

M_z – the mass of the workpiece, M_z = .0,384 kg

$$K_{v.m} = \frac{0,235}{0,384} \approx 0,61.$$

Analyzing the value of the coefficients of manufacturability, it can be concluded that it is necessary to choose a more technological method of obtaining the workpiece and assign rational values of allowances for machining in order to reduce the mass of the workpiece and increase the coefficient of use of the material.

1.4 Analysis of the basic technological process

The basic technological process of manufacturing parts involves small-part production. The technological process is characterized by a typical processing route for parts of this class.

Previously, it can be noted that the basic technological process of manufacturing is imperfect, since it is tied to the equipment that is available at the enterprise, which, although it provides requirements for the quality, accuracy, roughness of the surfaces of the part obtained, but binds us to specific production conditions. Accordingly, this technological process requires further work in order to improve.

As for the bases, they are chosen correctly in compliance with the principle of their unity and permanence. Also, the condition is met that at the first operation those surfaces are processed, which later serve as the basis for other operations. Some operations of the technological process should be replaced with more progressive ones that would increase processing productivity.

At the first operation of machining, the base is the cylindrical surface *B* of the part, which is no longer subject to machining, respectively, it is advisable to ensure its accuracy at the stage of manufacturing the workpiece.

From the point of view of reducing the cost of the product and the cost of preliminary machining of surface *B*, drilling can not be carried out with subsequent grinding. This will reduce the total processing time, since it will not be necessary to reinstall the part. vertical drilling is advisable to carry out not on a multi-spindle vertical drilling machine mod. 2S132, and on much cheaper mods. 2N125, which can provide technological requirements for the surfaces of the part. The horizontal-extended operation is impractical. This will reduce the cost of maintaining equipment, the production area of the site and increase the load factor of the equipment.

Modern technology of manufacturing parts involves, first of all, the use of the workpiece, the shape and dimensions of which would correspond as much as possible to the shape and size of the finished product, that is, the use of blanks obtained by casting in metal molds (coquil) or smelted or burnout models. The material of the part is cast iron CH20, respectively, the workpiece can be obtained only by casting [1].

a) casting in sand and clay forms;

b) casting in a coquel;

c) casting in half-steel forms.

The technology of processing parts in a similar production is characterized, first of all, by the use of progressive equipment and an increase in the fate of finishing.

Accordingly, it is recommended to use machine tools or semi-automatic machines, machines with built-in active control devices in the processing process.

It is also advisable to use special high-speed clamping devices with pneumatic, hydraulic, hydroplastic clamps that would meet the requirements of manufacturability, reliability and rigidity of the system. Modern technology attaches great importance to cutting tools, that is, the use of special hard alloys, metal equipment, elbor, diamond, and especially tools with mechanical fastening of carbide plates.

Accordingly, the use of the entire complex of the above measures allows you to get a high-precision technological detail with stable quality characteristics and minimal complexity and cost.

1.5 Conclusions and tasks for qualification work

As a result of the analysis of the design, manufacturability and basic technological processing of the part "hub 180.07.202" it can be concluded that in general the part is technological, does not cause much difficulty in the manufacture, the material and design of the parts are sufficiently worked out for manufacturability.

When performing work, it is necessary to improve the existing technological process in order to improve it in accordance with the proposed measures, that is, to develop an optimal technological process of machining, in which the shortcomings identified in the basic technological process should be eliminated, to choose modern technological equipment and necessary equipment, to choose a more rational way to obtain the workpiece, to calculate the allowances for processing, cutting modes and time standards for operations. It is necessary to select effective technological equipment, equipment and the necessary cutting tool for the operations of the developed technological process, as well as inthe selection of devices for machining, to calculate the error of installing the part in the proposed device, as well as the calculation and choice of the device drive.

In addition, it is necessary to consider the safety of life and the basics of labor protection in case of emergencies at the enterprise.

2 TECHNOLOGICAL PART

2.1 Setting the type ofproduct

According to the manufacturer, the type of production is small-part. According to GOST 14.312-74, two main forms of production organization are established: group and streaming.

The group form of production organization is characterized by uniformity of structural and technological features of products, unity of means of technological equipment of one or more technological operations and specialization of workplaces.

The streaming method of work is a progressive form of organization of production in mechanical engineering. The most effective results of its use are given in mass production, but it is also introduced into mass production.

We accept the organizational form of production – group.

We carry out technical rationing of works for small-syringe production. The value of the volume of production [2]

$$t_v = \frac{F_d \cdot 60}{N}, \qquad (2.1)$$

where F_d is a valid annual fund of equipment operation time, h.; F_d = 4015 hours;
N – annual program for the release of parts, pcs.; N = 6000 pcs.

$$t_v = \frac{4015 \cdot 60}{6000} = 40{,}15 \text{ Min.}$$

Number of parts for simultaneous launch into production [2]

$$n = \frac{N \cdot a}{F}, \qquad (2.\ 2)$$

where N is the annual program for the release of parts, pcs.; N = 6000 pcs.
a – the number of days for which it is necessary to have a stock of parts, a = 5;
F is the number of working days per year, F = 250 days.

$$n = \frac{6000 \cdot 5}{250} = 120 \text{ Piece.}$$

2.2 Choosing how to get the workpiece

The method of obtaining the workpiece is determined by the design of the part, material, technical requirements, seriality of production, as well as the efficiency of manufacturing. The material of the part is steel SCH20, respectively, the workpiece can be obtained in the following ways [1]:

a) casting in sand and clay forms;

b) casting in a coquel.

Casting in sand and clay forms. This process is a universal method of casting. talc, graphite; as dyes – marshalite, magnesite, zirconium. note the versatility and simplicity of the process, as shortcomings – low accuracy of the shape of the blanks.

Casting in coquil (metal molds). The material for their manufacture are cast iron grades VCH50, SCH18; steel 25, 35; U7, U10; alloy steels 30HGS. 5 г500 kg Application: simple in configuration castings of cast iron, steel and nonferrous metals in serial and mass production.

Advantages: multiple use; high accuracy of the shape and its size, high-quality surface of the workpiece; fine-grained structure of the material; high productivity; low labor intensity and cost of blanks; lack of model and stock equipment and molding mixtures; suitability for mechanization and automation.

Disadvantages: the formation of cracks in the overall workpieces, the impossibility of making thin-walled castings.

Of the possible options for obtaining a workpiece, the one that, after calculating the cost, will be more economical is taken. The cost of the workpiece can be calculated using the formula [2]

$$S_{zag} = \left(\frac{C_i}{1000} \cdot Q \cdot K_T \cdot K_C \cdot K_B \cdot K_M \cdot K_O \right) - (Q - q) \frac{S_{vid}}{1000}, \qquad (2.\ 3)$$

where C_i – the basic cost of 1 ton of blanks, UAH;

K_T, K_C, K_B, K_M, K_O – coefficients that depend on the accuracy class; group of complexity; mass; brand of material; volume of production of blanks;

Q – workpiece weight, kg;

The approximate mass of the workpiece can be found according to the following formula [1]

$$Q = \gamma \cdot K_P \cdot V_D, \tag{2. 4}$$

where – the specific mass of the γ material, γ = 7.8 g/cm^3;

K_P is a coefficient that takes into account the presence of allowances, K_P = 1.02... 1,5;

V_D – the volume of the part (the volume of the part is the sum of the volumes of its components).

q – mass of the finished product, q = ;0,235 kg

S_{vid} – the cost of 1 ton of waste, S_{vid} = 1400 UAH.

Option 1: casting in sand and clay forms

C_i = 27400 UAH.; K_T = 1; K_C = 1.15; K_B = 1.3; K_M = 1; K_O = 1 [2]; K_P = 1.1.

$$Q = 7{,}7 \cdot 1{,}2 \cdot 41{,}56 \approx 384 \text{ d} = 0{,}384 \text{ kg}$$

$$S_{zag1} = \left(\frac{27400}{1000} \cdot 0{,}384 \cdot 1 \cdot 1{,}15 \cdot 1{,}3 \cdot 1 \cdot 1\right) - (0{,}384 - 0{,}235)\frac{1400}{1000} = 15{,}52 \text{ UAH}$$

Option 2: Casting in a coquel

C_i = 29700 UAH.; K_T = 1; K_C = 1; K_B = 1.20; K_M = 1; K_O = 1 [2]; K_P = 1.02.

$$Q = 7{,}7 \cdot 1{,}2 \cdot 33{,}98 \approx 314 \text{ d} = 0{,}314 \text{ kg}$$

$$S_{zag2} = \left(\frac{29700}{1000} \cdot 0{,}314 \cdot 1 \cdot 1 \cdot 1{,}2 \cdot 1 \cdot 1\right) - (0{,}314 - 0{,}235)\frac{1400}{1000} = 11{,}08 \text{ UAH}$$

As you can see from the calculations, option 2 is more economical – casting in a coquil. The economic effect on the release program is determined by comparing the two options

$$E_z = \left(S_{zag1} - S_{zag2}\right) \cdot N \text{ ,(2.5)}$$

where N is the annual program for the release of parts, pcs.; N = 6000 pcs.

$$E_z = (15,52 - 11,08) \cdot 6000 = 26640 \text{ UAH}$$

Consequently, the method of obtaining a workpiece by casting in a coquil is more economically feasible. Economic effect compositione 26640 UAH.

Based on the analysis of technological capabilities, the characteristics of the proposed methods of obtaining blanks and their cost , we take the starting workpieceobtained by casting into a coquel.

The results of calculations are reduced to Table 2. 1.

Table 2. 1 – Comparative data of project blanks

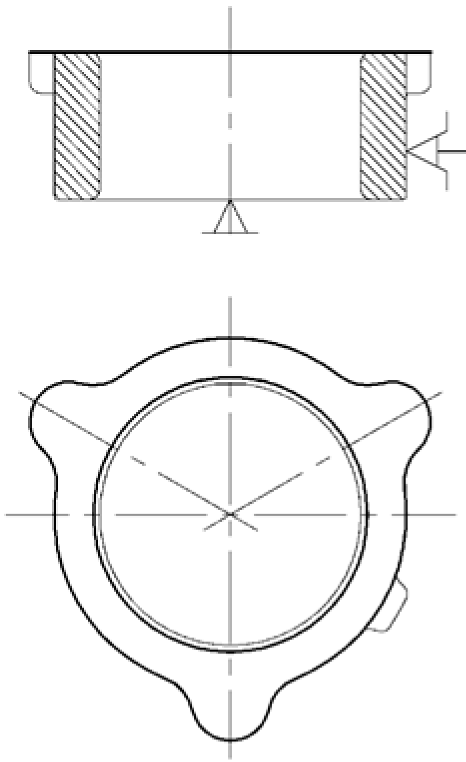
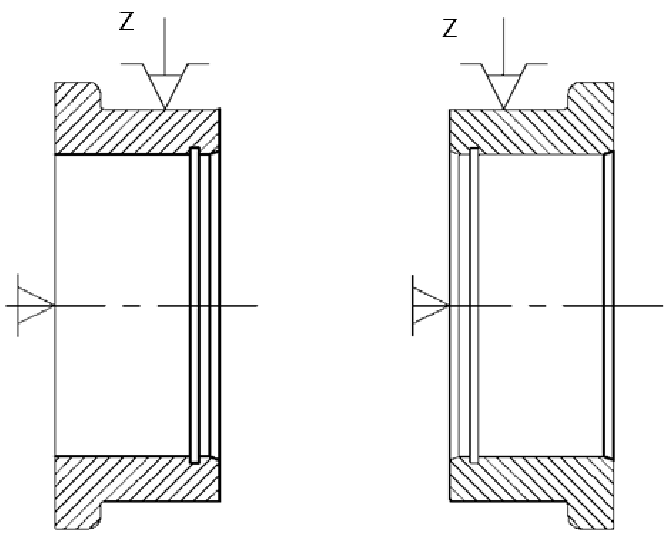
Characteristics of the workpiece	Variant	
	first	second
Type of workpiece	casting in sand and clay forms	casting in a coquel
Weight of part, kg	0,235	0,235
Workpiece weight, kg	0,384	0,314
The cost of the workpiece, UAH	15,52	11,08
Economic effect of the annual program, UAH	—	26640

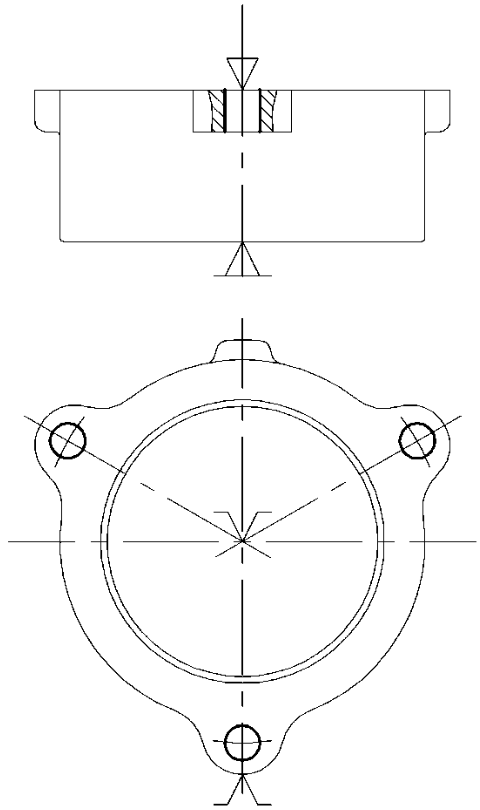
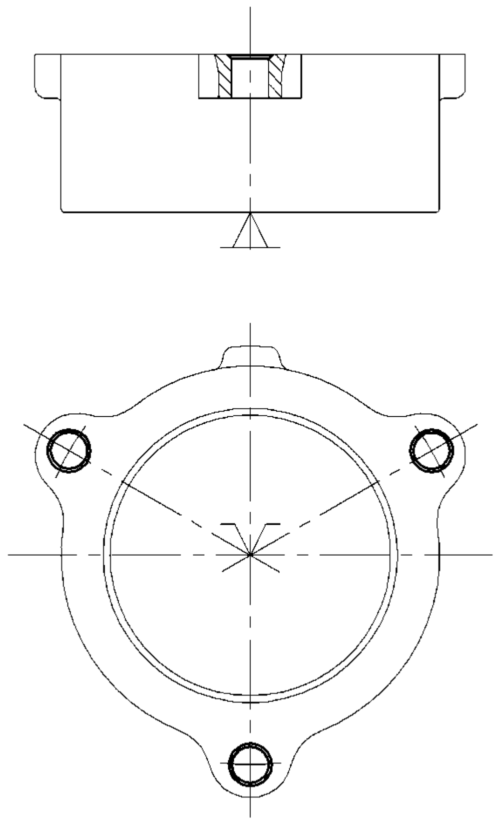
2.3 Selection of technological bases

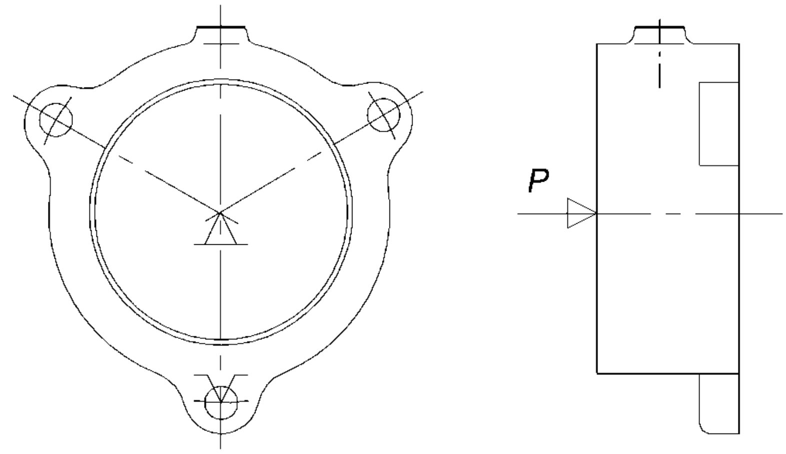
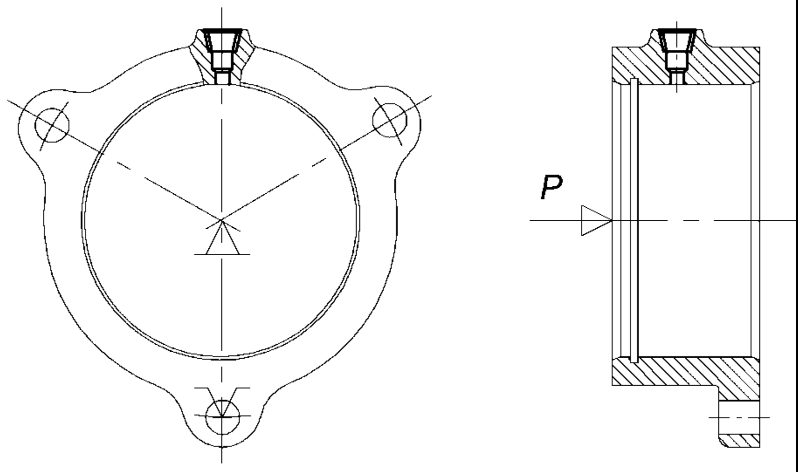
With the specified requirements for the accuracy of processing, it is necessary to choose such a basing scheme that provides the slightest error of the installation.

The results of the selection of basing schemes are reduced to Table 2.2.

Table 2.2 – Basing and pinning schemes

No operas.	Operation Name	Basing scheme
1	2	3
005	Vertical milling	
010	Turning	

015	Vertical drilling	
020	Vertical drilling	

025	Vertical milling	
030	Vertical drilling	

2.4 Design of the technological route of mechanical processing of parts

The purpose of the formation of the route and technological process is to develop two options for the manufacture of parts, and it is necessary, if possible, to ensure the replacement of equipment with more progressive and the same or cheaper, which, however, provides the necessary processing accuracy, which will increase productivity and reduce the cost of machining. These measures will reduce the cost of maintaining equipment, the production area of the site and increase the load factor of the equipment.

Consider various options for technological processes of machining of the product in order to choose the optimal one. The routes for processing technological processes are given, respectively, in Tables 2.3 and 2.4.

Table 2.3 – The first mof arshrut machining parts

No operation	Name of the transition operation	Processed Surface	Base surfaces	Equipment Mod.
1	2	3	4	5
005	Vertical drilling 1. Drill the hole pre-	*C*	*B, D*	2N135
010	CNC Turning 1. Grind the hole	*C*	*B, L*	16K30F3
015	Vertical drilling 1. Drill 3 holes at the same time	*A*	*B, D, K*	2S132
020	Vertical drilling 1. Zenky alternately 3 chamfers	*A*	*B, D, K*	2S132
025	Vertical drilling 1. Drill a hole 2. Drill a hole 3. Zenk chamfer 4. Cut the thread	*E, G, I,H*	*A, B*	2S132
030	Milling with CNC 1. Mill the plane of the end 2. Reinstall the part 3. Mill the plane	*H, J*	*B, D, L*	6P13F3
035	Horizontal-extended 1. Stretch hole	*C*	*B, L*	7B56
040	CNC Turning 1. Flow groove, end and chamfer 2. Reinstall the part 3. Sink the chamfer	*K, M, L*	*B, O*	16K30F3
045	Locksmith 1. Clean the zausenitsa	All	—	—
050	Flushing 1. Thyme the part	All	—	M2A
055	Control 1. Control technight requirements	All	—	PR1466

Table 2.4 – Second marcrut machining parts

No operation	Name of the transition operation	Processed Surface	Base surfaces	Equipment Mod.
1	2	3	4	5
005	Vertical milling 1. Mill the plane of the end	*O*	*B, L*	6N10
010	Tokarna 1. Trim the end 2. Grind the hole with the removal of the chamfer 3. Sink the groove 4. Reinstall the part 5. Remove the chamfer	*L, C, M, K, N*	*B, O, L*	1A720
015	Vertical drilling 1. Drill 3 holes at the same time	*A*	*D, L, C*	2N125
020	Vertical milling 1. Mill the plane	*J*	*A, B*	6N10
025	Vertical drilling 1. Drill a hole 2. Drill a hole 3. Zenk chamfer 4. Cut the thread	*E, G, I,H*	*A, B*	2N125
030	Locksmith 1. Clean the zausenitsa	All	—	—
035	Flushing 1. Thyme the part	All	—	M2A
040	Control 1. Control technical requirements	All	—	PR1466

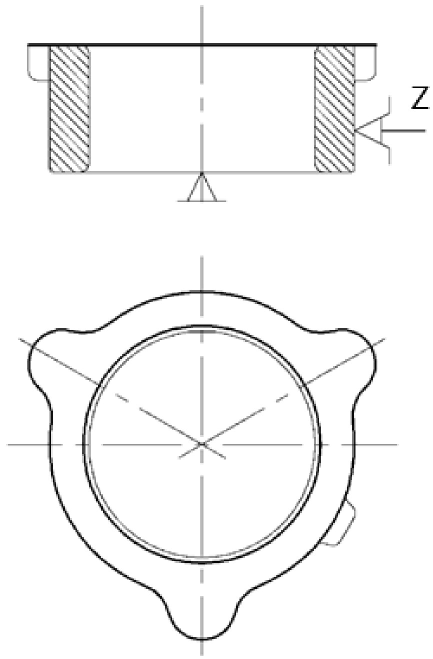
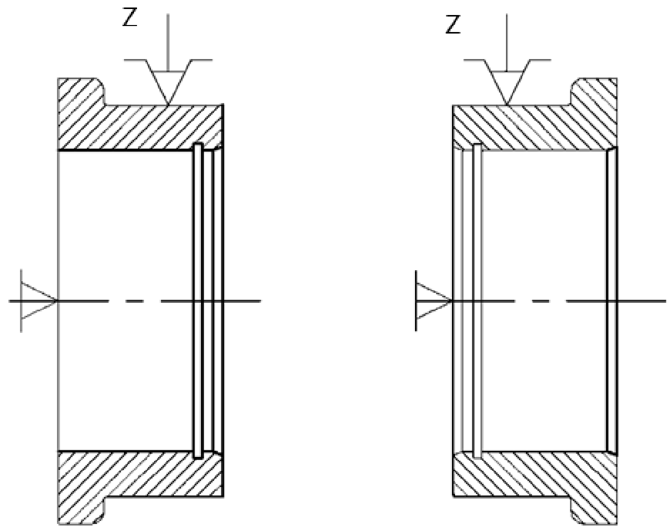
From the point of view of reducing the cost of the product and the cost of preliminary machining of surface B , it is possible not to drill with subsequent grinding, but only by grinding with the provision of the final size . this will reduce the cost of maintaining equipment (semi-automatic provides the necessary processing accuracy, and is much cheaper than the CNC machine). The same applies to the milling operation with CNC. Vertical drilling and radially drilling operations are advisable not on a multi-spindle vertical drilling mod machine. 2S132, and on much cheaper mods. 2N125, which can provide technological requirements for the surfaces of the part. Operation 035 (horizontal-extended) is impractical, since the quality and accuracy of the hole can be ensured by toting without subsequent calibration.

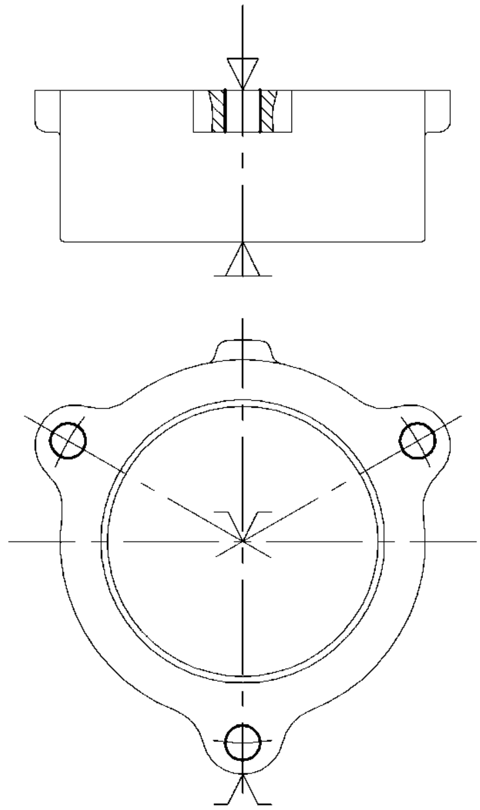
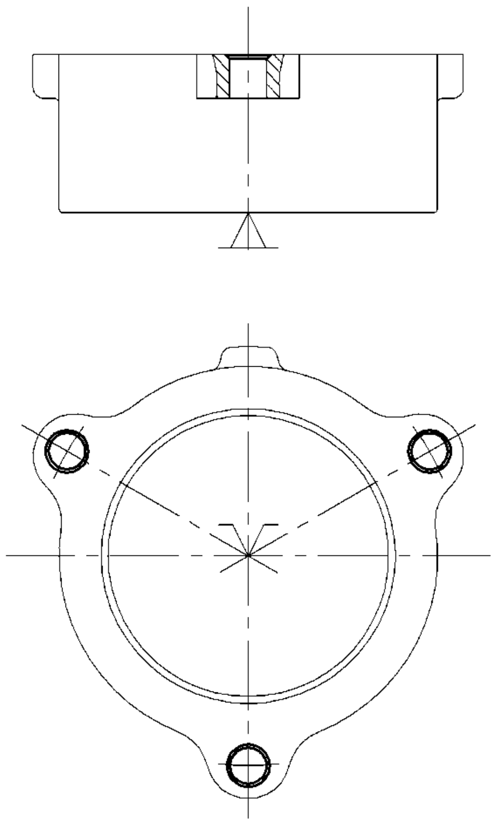
Accordingly, in the second version of the technological process of making the lid, individual equipment was replaced by a more uniform and cheaper one, which, however, provides the necessary processing accuracy, which will increase productivity and reduce the cost of machining. These measures will reduce the cost of maintaining equipment, the production area of the site and increase the load factor of the equipment.

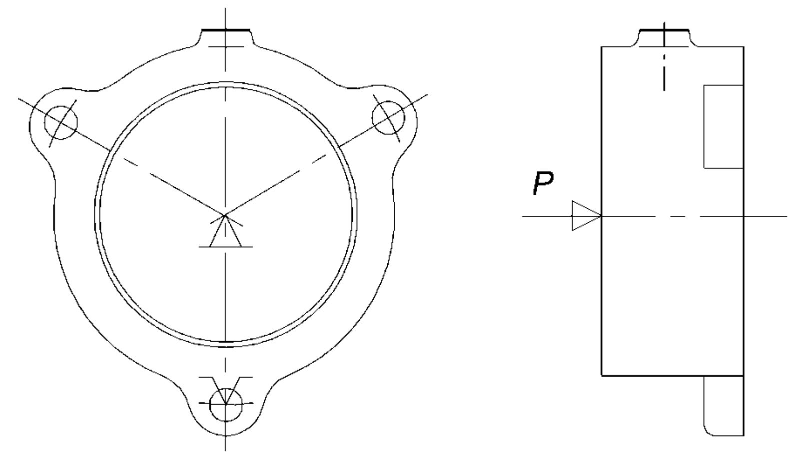
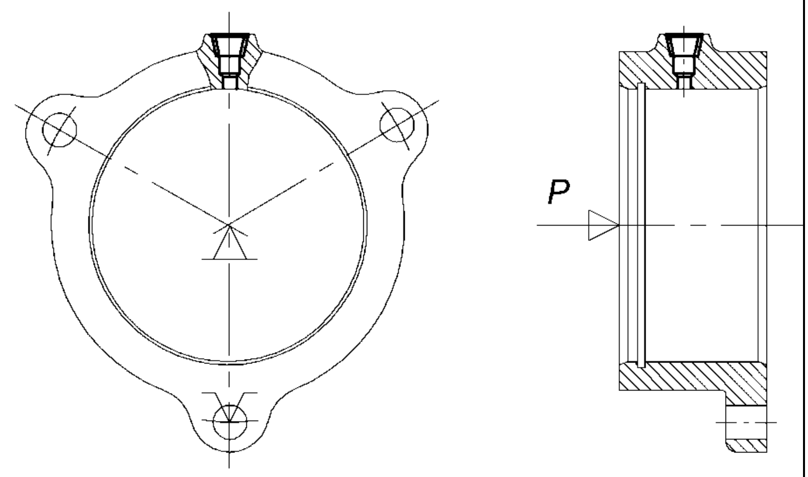
So, for further development, we accept the second version of the technological process of manufacturing the part "hub 180.07.202".

The results of the choice of basing schemes on the principle of combining bases – technological, measuring, installation, reduced to Table 2.5.

Table 2.5 – Basing and pinning schemes

No operas.	Operation Name	Basing scheme
1	2	3
005	Vertical milling	
010	Turning	

015	Vertical drilling	
020	Vertical drilling	

025	Vertical milling	
030	Vertical drilling	

2.5 Determination of processing allowances

The calculation of allowances for processing is carried out in accordance with the recommendations [2, 14]. For the supervision of this technique, we will calculate the allowances and interoperative dimensions for the treatment of surfaces L, Oin size $43^{+0,6}$ mm.

The technological route of processing this surface consists of the following transitions:

1. Milling;
2. Clean sharpening.

We calculate the allowances for surface treatment.

For casting: R_z = 150 microns; T = 250 microns;

1. Milling: R_z = 30 microns; T = 30 microns;
2. Finishing sharpening: R_z = 5 microns; T = 15 microns.

The total value of spatial deviations when basing the part [2]

$$\rho_z = \sqrt{\rho_{kor}^2 + \rho_{cm}^2}\ , \tag{2.6}$$

where ρ_{kor} is the value of the box, μm;
ρ_{cm} – total displacement, μm.

The value of the box is equal

$$\rho_{kor} = \Delta_k l\ , \tag{2.7}$$

where Δ_k is the specific curvature of the workpiece, Δ_k = 1.5 microns/mm;
l – the length of the workpiece, l = 47 mm.

$$\rho_{kor} = 1,5 \cdot 140 \approx 71 \text{ Microns.}$$

The total displacement is equal to

$$\rho_{cm} = \sqrt{\left(\frac{\delta_1}{2}\right)^2}\ , \tag{2. 8}$$

where δ_1 is the tolerance for the size that determines the position of the base surface during processing, δ_1 = 200 microns.

$$\rho_{cm} = \sqrt{\left(\frac{200}{2}\right)^2} = 100 \text{ Microns.}$$

$$\rho_z = \sqrt{71^2 + 100^2} \approx 123 \text{ Microns.}$$

The amount of residual spatial deviation after transitions

$$\rho_1 = 0,05\rho_3 = 0,05 \cdot 123 \approx 6 \text{ Microns;}$$

$$\rho_2 = 0,05\rho_1 = 0,05 \cdot 6 \approx 0,3 \text{ Microns.}$$

The basing error occurs due to a possible distortion of the workpiece during its installation in the cartridge. The maximum gap value is equal to

$$S_{\max} = \delta_A + \delta_B + s_{\min}, \qquad (2.9)$$

where δ_A is the tolerance to the diameter of the installation surface, δ_A = 16 microns; δ_B – admission to perform the fastening element, δ_B = 14 microns;
$s_{\min}$ – minimum gap, $s_{\min}$ = 13 microns.

The maximum angle of rotation of the workpiece

$$tg\alpha = \frac{\delta_A + \delta_B + s_{\min}}{L_c}, \qquad (2.10)$$

where L is the linear length of the workpiece, L mm = 47

$$tg\alpha = \frac{0{,}016 + 0{,}014 + 0{,}013}{47} \approx 0{,}0009.$$

Basing error by the length of the treated surface

$$\varepsilon_b = l \cdot tg\alpha. \qquad (2.11)$$

$$\varepsilon_b = 43 \cdot 0{,}0009 \approx 0{,}04 \text{ mm} = 40 \text{ microns}.$$

Error of fixing the workpiece ε_z = 40 microns [2]. Installation error during milling

$$\varepsilon_1 = \sqrt{\varepsilon_b^2 + \varepsilon_z^2}. \qquad (2.12)$$

$$\varepsilon_1 = \sqrt{40^2 + 40^2} \approx 57 \text{ Microns}.$$

Installation error for finishing tochinny

$$\varepsilon_2 = 0{,}05 \cdot \varepsilon_1. \qquad (2.13)$$

$$\varepsilon_2 = 0{,}05 \cdot 57 \approx 3 \text{ Microns}$$

Minimum values of interoperative allowances [2]

$$2Z_{\min} = 2\left(R_{Zi-1} + T_{i-1} + \rho_{i-1}\right). \qquad (2.14)$$

Minimum allowance for processing

$$2Z_{\min 1} = 2(150 + 250 + 123) = 2 \cdot 523 \text{ Microns;}$$

$$2Z_{\min 2} = 2(30 + 30 + 6) = 2 \cdot 66 \text{ Microns.}$$

The estimated size l_p is determined starting from the final size by sequential addition of the estimated minimum allowance of each technological transition.

$$l_{p1} = 43 + 0{,}132 = 43{,}132 \text{ mm;}$$

- for the workpiece

$$l_{p2} = 43{,}132 + 1{,}046 = 44{,}178 \text{ mm.}$$

The values of the size limits will be as follows:

- for finishing sharpening $l_{\min ZAG} = 42{,}8$ mm;

$$l_{\max ZAG} = 42{,}8 + 0{,}2 = 43 \text{ mm;}$$

- for milling $l_{\min ZAG} = 43{,}15$ mm;

$$l_{\max ZAG} = 43{,}15 + 0{,}25 = 43{,}4 \text{ mm;}$$

- for the workpiece $l_{\min ZAG} = 43{,}45$ mm;

$$l_{\max ZAG} = 43{,}45 + 3{,}2 = 46{,}65 \text{ mm.}$$

The minimum threshold values of allowances are equal to the difference of the smallest size limits of the executing and previous sizes, and the maximum values of the difference of the largest limit sizes. $2z_{\min}^{np}$ $2z_{\max}^{np}$

$$2z_{\min 2}^{np} = 43{,}15 - 42{,}8 = 0{,}35 \text{ mm} = 350 \text{ microns};$$

$$2z_{\max 2}^{np} = 43{,}4 - 43 = 0{,}4 \text{ mm} = 400 \text{ microns};$$

$$2z_{\min 1}^{np} = 44{,}45 - 43{,}15 = 1{,}3 \text{ mm} = 1300 \text{ microns};$$

$$2z_{\max 1}^{np} = 47{,}65 - 43{,}4 = 4{,}25 \text{ mm} = 4250 \text{ microns}.$$

General allowances $z_{O\min}$ and $z_{O\max}$

$$2z_{0\min} = 350 + 1300 = 1650 \text{ Microns};$$

$$2z_{0\max} = 400 + 4250 = 4650 \text{ Microns}.$$

Total nominal allowance

$$z_{0nom} = z_{0\min} + H_Z - H_D, \qquad (2.15)$$

where H_Z is the lower deviation of the workpiece, μm;
H_D – lower deviation of the part, μm.

$$H_Z = N_i + \frac{K_y}{2}, (2.16)$$

where N_i – tolerance for wear of the tool, N_i = ;0,8 mm
K_y – shrinkage oscillation, K_y = 1.0 μm/mm.

$$H_z = 0{,}8 + \frac{1{,}0}{2} = 0{,}4 \text{ mm} = 400 \text{ microns}.$$

$$z_{0_{ном}} = 1650 + 400 - 200 = 1850 \text{ microns}.$$

Nominal size of the workpiece

$$l_{Znom} = l_{Dnom} + z_{onom} \text{ mm}. \qquad (2.17)$$

$$l_{znom} = 43{,}6 + 1{,}85 = 45{,}45 \text{ mm}.$$

We will check the correctness of the calculated allowances and sizes

$$z_{\max 2}^{np} - z_{\min 2}^{np} = \delta_1 - \delta_2;$$

400 – 350 = 250 – 200;

50 = 50.

$$z_{\max 1}^{np} - z_{\min 1}^{np} = \delta_3 - \delta_2;$$

4250 – 1300 = 3200 – 250;

2950 = 2950.

– therefore, the calculations were carried out correctly.

The results are translated into Table 2.6.

Table 2.6 – Calculation of allowances for limit sizes for technological transitions to surface treatment *L*, *O* in size $43^{+0,6}$ mm

Technological transitions of processing	Omitting elements, μm				Estimated allowance $2Z_{\min}$	Estimated size l_p, mm	Tolerance , μmδ	Limit size		Allowance thresholds, μm	
	R_z	T	ρ	ε				$l_{\min}$	$l_{\max}$	$2z_{\min}^{np}$	$2z_{\max}^{np}$
Blank	150	250	123	–	–	44,178	3200	43,45	46,65		
1. Milling	30	30	6	57	4·523	43,132	250	43,15	43,4	1300	4250
2. Pure sharpening	5	15	0,3	3	2·66	43	200	42,8	43	350	400
										1650	4650

The scheme for placing allowances and tolerances for processing is shown in Figure 2.1.

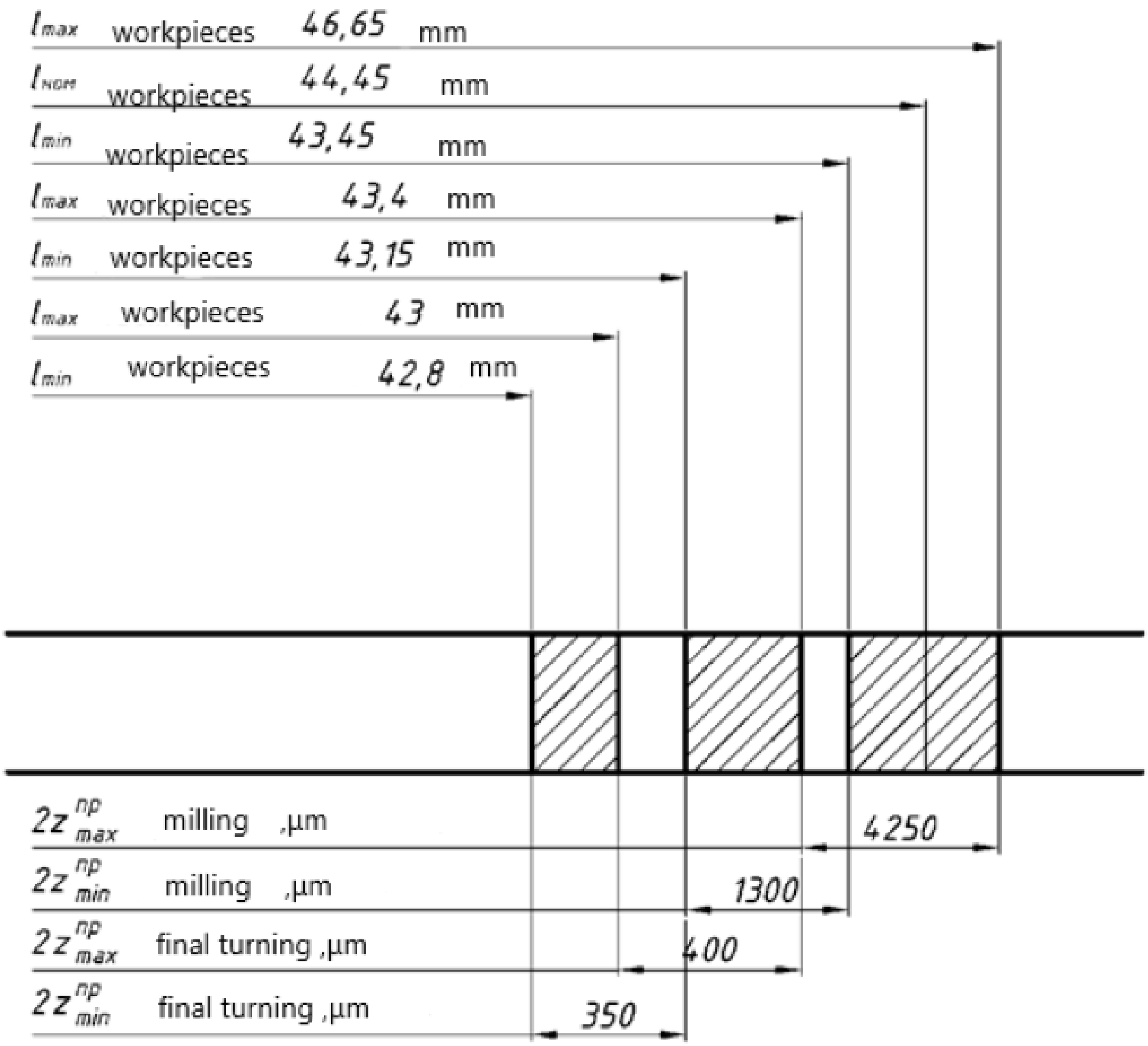


Figure 2.1 – Scheme of placement of allowances and tolerances for processing surfaces *L*, *O* in size $43^{+0,6}$ mm

2.6 Calculation and selection of processing modes and technical standards of time

Calculation of cutting modes is carried out by the calculation and analytical method and using regulatory data.

Operation 005 – vertical milling

Cutting depth t = 2 mm; number of passes i = 1; number of teeth cutters z = 12; milling width B = 39 mm; feed S_z = 0.08 mm / tooth [14].

The cutting speed is determined according to the recommendations [14]

$$V = \frac{C_v \cdot D^q \cdot K_m \cdot K_n \cdot K_N \cdot K_f}{T^m \cdot t^x \cdot S^y \cdot z^n \cdot B^z}, \qquad (2.18)$$

where C_v is a constant coefficient, C_v = 64.7 [14];

D – cutter diameter, D = 45 mm; q, m, x, y, p, z – power indicators,

q = 0,25; m = 0,2; x = 0.15; y = 0,6; p = 0.1; z = 0,1 [14];

T – the period of stability of the tool, T = 180 min. [14];

K_m, K_n, K_N, K_f – correction coefficients, K_m = 1; K_p = 0.9; K_N = 1.3; K_f = 1 [14].

$$V = \frac{64{,}7 \cdot 45^{0,25} \cdot 1 \cdot 0{,}9 \cdot 1{,}3 \cdot 1}{180^{0,2} \cdot 2^{0,15} \cdot 0{,}08^{0,2} \cdot 12^{0,1} \cdot 39^{0,1}} = 56{,}8 \text{ m/min.}$$

Spindle rotation number

$$n = \frac{1000 \cdot 56{,}8}{3{,}14 \cdot 45} = 401{,}9 \text{ rpm.}$$

Adjust the calculated value of the numbers of revolutions with the passport data of the machine (mod.6N10) p = 400 rpm.

$$V = \frac{\pi D n}{1000} = \frac{3{,}14 \cdot 45 \cdot 400}{1000} = 56 \text{ m/min.}$$

Minute feed

$$S_m = S_z \cdot z \cdot n. \qquad (2.19)$$

After substitution of data, we obtain

$$S_m = 0{,}08 \cdot 12 \cdot 400 = 384 \text{ mm/min.}$$

Effective cutting power is calculated according to the formula [14]

$$N_e = \frac{P \cdot V}{60 \cdot 102}, \tag{2.20}$$

where P is the circular cutting force, H

$$P = C_p \cdot t^x \cdot S_z^y \cdot z \cdot B^z \cdot D^q, \tag{2.21}$$

where C_p is a constant coefficient, C_p = 68 [14];

q, x, y, z – exponential indicators, q = - 0.86; x = 0.86; y = 0,74; z = 1 [14].

$$P = 68 \cdot 1^{0,86} \cdot 0{,}08^{0,74} \cdot 12 \cdot 39^1 \cdot 45^{-0,86} = 211 \text{ kN.}$$

Efficient cutting power

$$N_e = \frac{211 \cdot 56}{60 \cdot 102} = 1{,}93 \text{ Kw.}$$

Main time

$$T_o = \frac{L}{S_m}, \tag{2.22}$$

where L is the total cutting length, mm.

$$L = B_L + y_1 + y_2, \tag{2.23}$$

where B_L is the length of milling, B_L = ;170 mm

y_1 – tool liner value, y_1 = 10 mm;

y_2 – tool progress value, y_2 = 10 mm.

$$L = 170 + 10 + 10 = 190 \text{ mm;}$$

$$T_o = \frac{190}{120} = 1{,}58 \text{ Min.}$$

Operation 020 – vertical drilling

Cutting depth = 0.510 = ; number of passes $t = 0{,}5D \cdot 5$ mm i = 1; feed S = 0.2 mm/r [14]. Cutting speed [14]

$$V = \frac{C_v \cdot D^q}{T^m \cdot S^y} \cdot K_v, \qquad (2.24)$$

where C_v is a constant coefficient, C_v = 8.9 [14];

D – drill diameter, D = ;10 mm

q, m, y – exponential indicators, q = 0.35; m = 0,2; y = 0,6 [14];

T – the period of stability of the tool, T = 60 min. [14];

K_v is the correction coefficient, K_v = 0.72 [14].

$$V = \frac{8{,}9 \cdot 10^{0{,}35}}{60^{0{,}2} \cdot 0{,}2^{0{,}6}} \cdot 0{,}72 = 17{,}78 \text{ m/min.}$$

Spindle rotation number

$$n = \frac{1000V}{\pi D}. \qquad (2.25)$$

After substitution of data, we obtain

$$n = \frac{1000 \cdot 17{,}78}{3{,}14 \cdot 12} = 472 \text{ rpm.}$$

Adjust the calculated value of the numbers of revolutions with the passport data of the machine (mod.2N125) p = 425 rpm.

$$V = \frac{\pi D n}{1000} = \frac{3{,}14 \cdot 12 \cdot 425}{1000} \approx 16{,}01 \text{ m/min.}$$

Cutting power efficiency [14]

$$N_e = \frac{M_K \cdot n}{975 \cdot 1000}, \quad (2.26)$$

where M_K is torque, H

$$M_K = C_m \cdot D^{2.0} \cdot S^y \cdot K_m, \quad (2.27)$$

where C_m is a constant coefficient, C_m = 39 [14];
y – power indicator, y = 0.8 [14];
K_m – correction coefficient, K_m = 0.78 [14].

$$M_K = 39 \cdot 10^{2.0} \cdot 0{,}2^{0{,}8} \cdot 0{,}78 = 1208{,}7 \approx 1209 \text{ Nm.}\cdot$$

Efficient cutting power

$$N_e = \frac{1209 \cdot 425}{975 \cdot 1000} \approx 0{,}53 \text{ Kw.}$$

Main time

$$T_o = \frac{L}{n \cdot S}, \quad (2.28)$$

where L is the total cutting length, mm;

$$L = t + y_1 + y_2, \quad (2.29)$$

where t is the cutting length, t = ;12 mm
y_1 – tool liner value, y_1 = ;3 mm
y_2 – tool progress value, y_2 = .3 mm

$$L = 12 + 3 + 3 = 18 \text{ Mm.}$$

$$T_o = \frac{18}{425 \cdot 0,2} = 0,21 \text{ Min.}$$

Calculations of cutting modes for other technological operations are carried out in accordance with the recommendations of the reference literature [13, 14] and the results are entered in Table 2.7.

Table 2.7 – Cutting modes for operations of the technological process

№ Operas.	Operation Name and transition	*L*, Mm	*t*, Mm	*i*	*S*, mm/ob	S_m, mm/min.	*n*, rpm.	*V*, m/min.	T_o, Min.	*N*, Kw
1	2	3	4	5	6	7	8	9	10	11
005	Vertical milling Transition 1	150	2	1	-	384	400	56	1,58	1,93
010	Tokarna Transition 1 Transition 2 Transition 3 Transition 5	11 30 5 4	2,3 2 1,75 2	1 1 1 1	0,4 0,2 0,4 0,2	- - - -	200 250 200 200	93 68 93 62	0,31 1,52 0,24 0,18	1,31
015	Vertical drilling Transition 1	12	5	1	0,2	-	425	16,01	0,36	0,53
020	Vertical drilling Transition 1 Transition 2 Transition 3	3 3 3	1 1 1	1 1 1	Manual Manual Manual	- - -	355 355 355	13,4 13,4 13,4	0,18 0,18 0,18	0,35
025	Vertical milling Transition 1	17	2	1	-	284	350	43	0,44	0,62
030	Vertical drilling Transition 1 Transition 2 Transition 3	20 17 2	2 2,3 1	1 1 1	Manual Manual Manual	- - -	710 500 200	8,9 13,5 8,4	0,6 0,34 0,11	0,22

	Transition 4	17	-	1	0,941	-	250	7,9	0,16	
035	Locksmith	-	-	-	-	-	-	-	-	-
040	Flushing	-	-	-	-	-	-	-	-	-
045	Reception control	-	-	-	-	-	-	-	-	-

Technical norms of time for operations of the technological process of machining are established in a calculated and analytical way.

The norms of artificial time per operation are determined by the formula [8]:

$$T_{sht} = T_o + T_d + T_{obs} + T_{vid}, \quad (2.30)$$

where T_o – basic (technological) time, min.;

T_d – auxiliary time, min.;

T_{obs} – time for servicing the workplace, min.;

T_{vid} – time for rest and natural needs of the worker, min.

The sum of the main and auxiliary time is operational time

$$T_{op} = T_o + T_d. \quad (2.31)$$

In serial production, the preparatory and final time and artificial calculation time are additionally calculated

$$T_{sht.k} = T_{sht} + \frac{T_{p.z.}}{n}, \quad (2.32)$$

where $T_{p.z.}$ – preparatory and final time, min.

We calculate the norm of artificial time for the operation 015 – vertical drilling.

The main time for operation T_o = 0.36 min. Calculate the volume of auxiliary work and the time for their implementation is similar to the previous operation

1) T_{ust} = 0.64 min. [8];

2) T_{upr} = 0.48 min. [8];

3) T_{vym} = 0.08 min. [8].

General auxiliary time

$$T_d = 0,64 + 0,48 + 0,08 = 1,20 \text{ Min.}$$

Operational time for the operation

$$T_{op} = 0,36 + 1,20 = 1,56 \text{ Min.}$$

The time for servicing the workplace is 4% of the operational time [2]

$$T_{obs} = 0,04 \cdot 1,56 \approx 0,06 \text{ Min.}$$

Time for rest and natural needs is also 4% of the operational time [2]

$$T_{vid} = 0,04 \cdot 1,56 \approx 0,06 \text{ Min.}$$

Artificial time for surgery

$$T_{sht} = 1,56 + 1,2 + 0,06 + 0,06 = 2,88 \text{ Min.}$$

Preparatory and final time T_{pz} = 16 min.

Artificial calculus time

$$T_{sht.k} = 2,88 + \frac{16}{240} = 2,95 \text{ Min.}$$

Similarly, we carry out rationing for the remaining operations of the technological process and reduce the results in Table 2.8.

Table 2.8 – Artificial time norms for process transactions

Operation number	T_o, min	Auxiliary, min.			T_d, min	T_{op}, min	T_{obs}, min	T_{from}, min	$T_{pcs.}$, min	$T_{pz.}$, min	$T_{pcs.k}$ min
		T_{ust}	T_{upr}	T_{vym}							
1	2	3	4	5	6	7	8	9	10	11	12
005	1,58	0,64	0,48	0,08	1,2	1,8	0,11	0,11	2,33	24	3,12
010	2,08	0,64	0,48	0,08	1,2	3,28	0,13	0,13	4,74	16	4,81
015	0,36	0,64	0,68	0,08	1,2	1,56	0,06	0,06	2,88	12	2,95
020	0,18	0,64	0,68	0,08	0,69	0,92	0,06	0,04	0,86	12	1,05
025	0,44	0,64	0,48	0,08	1,2	1,28	0,09	0,10	1,57	16	2,81
030	1,21	0,64	0,48	0,08	1,2	2,28	0,13	0,13	3,24	16	3,62
035	–	–	–	–	–	–	–	–	0,25	9	0,37
040	–	–	–	–	–	–	–	–	0,35	5	0,57
045	–	–	–	–	–	–	–	–	0,56	12	0,75

3 DESIGN PART

3.1 Description of the design of the device for machining

For machining milling of the planes of the end surface, you can use the device principle of operation and the design of which is as follows. This device consists of a body of welded structure on which its other elements are mounted. The bases for the installation of the workpiece during machining are the end and cylindrical surfaces. The constituent elements are the cylindrical surface of the sleeve and pin. The downforce is transmitted from the pneumocylindra through the rod and the quickly removable puck.

To carry out technological operations "clamp-clamping parts" is used pneumorozpodilny crane, which with the help of pipelines is connected to the pneuumocylinder. The supply of compressed air to the pneuvocylindre is carried out from the pneuction system. Installing the device on the table
the machine is carried out with the help of 2 veneers and is fixed with mounting bolts through grooves on the sides of the body plate.

3.2 Calculation of adaptation error

To calculate the accuracy of the manufacture of the device, you can use the following dependence [2]

$$\varepsilon_{pr} = \delta - k\sqrt{(k_1\varepsilon_b)^2 + \varepsilon_z^2 + \varepsilon_{yst}^2 + \varepsilon_{zn}^2 + \varepsilon_{r.i}^2 + (k_2\omega)^2}\,, \qquad (3.1)$$

where δ – tolerance to the performing size, δ = 0,18 mm;
k – a coefficient that takes into account the possible deviation from the normal placement of individual components, k = 1.2;
ε_b – basing error, which is based on the following dependence [2]

$$\varepsilon_b = \frac{\delta_D}{2}, \qquad (3.2)$$

where δ_D is the tolerance to the installation surface, δ_D = 0,16 mm;

After substitution of data, we obtain

$$\varepsilon_b = \frac{0,16}{2} = 0,08 \text{ Mm.}$$

k_1, k_2 – production seriality coefficients, k_1 = 0.7; k_2 = 0,6;

ε_z – error, taking into account the displacement of the treated surfaces of the workpiece due to the action of downforce, ε_{with} = 0 mm;

ε_{yst} – error of installation of the device on the machine, mm;

$$\varepsilon_{yst} = \frac{L_d \cdot s_{sh}}{l}, \qquad (3.3)$$

where L_d is the length of the treated surface, L_d = 20 mm;

s_{sh} – the largest gap between the guide veneer of the approbation and the groove of the table, s_{sh} = 0,05 mm;

l – the distance between the veneers, l = 390 mm.

$$\varepsilon_{yst} = \frac{20 \cdot 0,05}{390} \approx 0,00128 \text{ Mm.}$$

ε_{zn} – error of wear of installation elements of the device, ε_{zn} = 0,02 mm;

$\varepsilon_{r.i.}$ – error of displacement of the cutting tool, ε_{ri} = 0,1;

ω – economic error for this processing method, ω = 0,08 mm.

The substitution of numeric values is obtained

$$\varepsilon_{np} = 0,18 - 1,2\sqrt{(0,7 \cdot 0,08)^2 + 0^2 + 0,00128^2 + 0,02^2 + 0,1^2 + (0,6 \cdot 0,08)^2} \approx 0,03 \text{ Mm.}$$

$\varepsilon < \delta$pr – therefore, the accuracy of processing is ensured.

The error in the installation of the output workpiece in the device is due to a number of technological factors that determine the value of the total error. To calculate the accuracy of the manufacture of the device, you can use the following dependence (3.1). δ 0,36 mm k = 1,2; ε_b = 0.18; k_1 = 0,7; k_2 = 0,6; ε_z = 0,1 mm; ε_{yst} = 0,041 mm; ε_{zn} = 0,04 mm; ε_{ri} = 0; ω = 0,1 mm.

The substitution of numeric values is obtained

$$\varepsilon_{np} = 0{,}36 - 1{,}2\sqrt{(0{,}7 \cdot 0{,}18)^2 + 0{,}1^2 + 0{,}041^2 + 0{,}04^2 + (0{,}6 \cdot 0{,}1)^2} \approx 0{,}142 \text{ Mm}$$

– therefore, the accuracy of processing is ensured.

3.3 Calculation of the device drive

The layout and basing of the part in the device is shown in Figure 3.1. During milling of the part with a mechanical cutter, the part is based on a prism with end stops. Accordingly, the clamping force acts normally to the surface of the workpiece and creates an effort that prevents the displacement of the workpiece under the influence of the cutting force.

The required clamping force P is determined from the following equality

$$Ff + F_1 f + F_2 f \geq kP_{cut}, \tag{3.4}$$

where F, F_1, F_2 are the components of friction forces on the clamping lever and prism;

f – friction coefficient at the contact point of the workpiece and constituent and clamping elements, f = 0.15;

P_{cut} – cutting force, P_{cut} = 70.5 N;

k is the stock factor.

The stock factor k can be represented as the product of primary coefficients [2]

$$k = k_1 \cdot k_2 \cdot k_3 \cdot k_4 \cdot k_5 \cdot k_6, \tag{3.5}$$

where k_1 is the guaranteed reserve coefficient, k_1 = 1.5;

k_2 – the coefficient of change in the value of the allowance for cleaning blanks, k_2 = 1.0;

k_3 – a coefficient that takes into account the increase in the cutting force when blunting the tool, k_3 = 1.2;

k_4 – correction coefficient for continuous milling, k_4 = 1.0;

k_5 – coefficient taking into account the pneuvozatsk of the part, k_5 = 1.0;

k_6 – correction coefficient at additional torques, k_1 = 1.5.

By substitution of primary coefficients in equality (5.10) we obtain

$$k = 1{,}5 \cdot 1{,}2 \cdot 1{,}0 \cdot 1{,}0 \cdot 1{,}0 \cdot 1{,}5 = 2{,}7 .$$

The components of friction forces can be expressed through clamping forces

$$F = F_1 = F_2 = P \cdot \cos\frac{\alpha}{2}, \qquad (3.6)$$

where α is the angle of inclination of the sides of the prism, α = 165°.

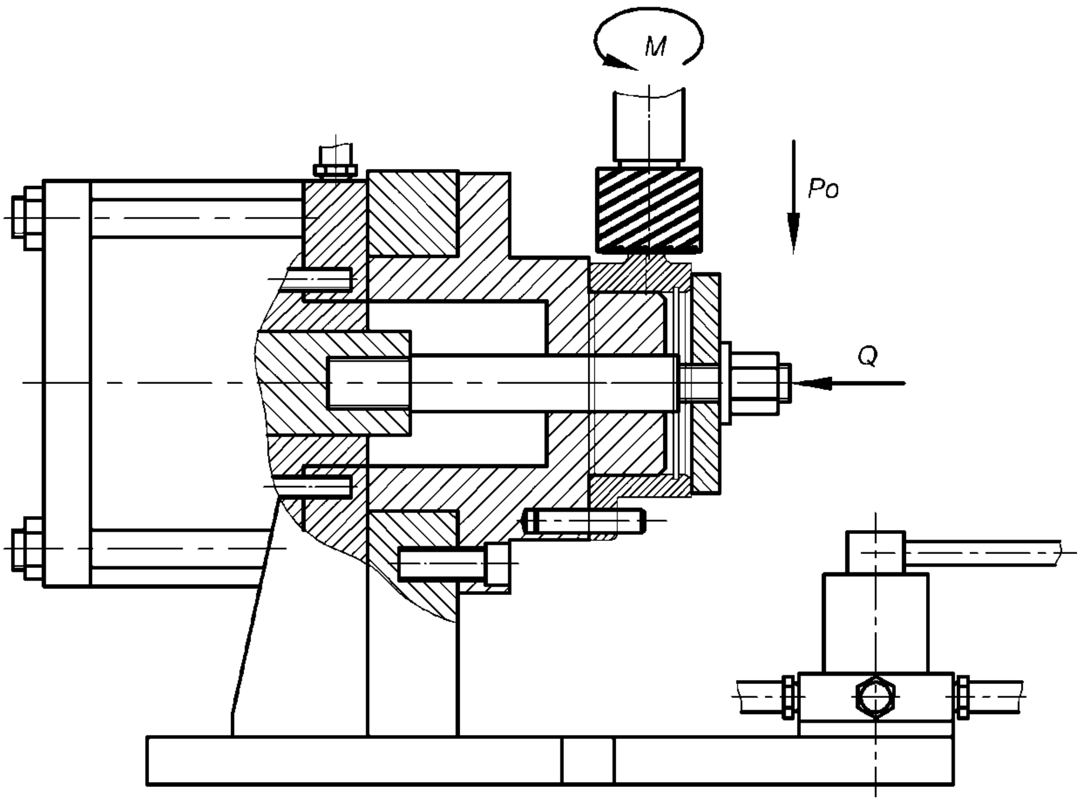


Figure 3.1 – Scheme of basing and clamping of parts in the device for milling the end surface

$$4P \cdot f \cdot \cos\frac{\alpha}{2} = kP_{cut}. \quad (3.7)$$

The relationship between the clamping force and the pneumocylindra force

$$P = Q \cdot \frac{l_2}{l_1}, \quad (3.8)$$

where l_1, l_2 is the length of the shoulders of the lever, m.

Accordingly, equality will take the form of

$$4Q \cdot \frac{l_2}{l_1} \cdot f \cdot \cos\frac{\alpha}{2} = kP_{cut}. \quad (3.9)$$

Where does the pneumocylindra force come from?

$$Q = \frac{kP_{cut} l_1}{4l_2 \cdot f \cdot \cos\frac{\alpha}{2}}. \quad (3.10)$$

By substituting numerical data to equality (3.10) we obtain

$$Q = \frac{2{,}7 \cdot 70{,}5 \cdot 0{,}04}{4 \cdot 0{,}055 \cdot 0{,}15 \cdot \cos\frac{165^\circ}{2}} \approx 1777 \text{ N.}$$

Calculation of the diameter of the pneumocilindra clamping device can be carried out according to the following dependence

$$Q = \frac{\pi\left(D^2 - d^2\right)}{4} \cdot p, \quad (3.11)$$

where D is the diameter of the pneumocylindra, cm;

d – diameter of the rod pneuvomocilindra, d = 4 cm;

p – working pressure in the pneuvosystem, p = 10 kg/cm^2.

Under

$$D = \sqrt{\frac{4Q}{\pi \cdot p} + d^2}. \quad (3.12)$$

Substitute the numerical data we obtain

$$D = \sqrt{\frac{4 \cdot 1777}{3{,}14 \cdot 10} + 4^2} = 15{,}57 \text{ cm} \approx 156 \text{ mm} .$$

Of the standard values of the diameters of pneuvomocylindres, we take the diameter of the pneumocilindra D = 160 mm, the diameter of the rod d = 40 mm [14].

3.4 Development of cutting tools

When designing a passing incisor, it is necessary, based on the working conditions and the method of fixing the carbide plate of the incisor, to calculate the strength of the soldering joint of the carbide plate with the incisor body (plate material - T15K6, stateswoman - steel 40).

The scheme of action of the component cutting force P_z on the cutter is shown in Figure 3. 2. Under the action of this force, the condition of strength on the cut is [14]

$$\tau_{zr} = \frac{P_z}{b \cdot l} \leq [\tau]_{zr} . \qquad (3.13)$$

When soldering with the help of the brand of solder AKP 45 strength limit on the cut [14] τ_{zr} = 450 MPa.

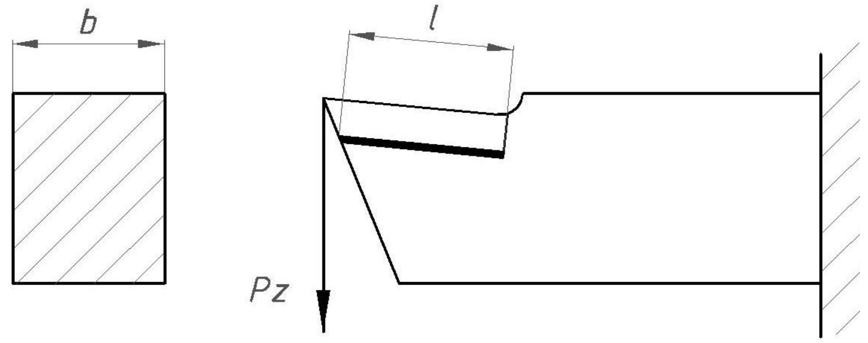


Figure 3. 2 – Calculation scheme for determining the strength of the soldering joint

The constructive dimensions of the incisor are taken fromthe adequate recommendations presented in [14] b = ; 10 mm$l$ = ; the length of the incisor 10 mm$L$ = ; height 100 mm$h$ = ; front surface angle = 10; the angle of inclination of the cutting edge = 8; the back surface = 10; the side surface of the cutting part 16 mmγ° φ° φ'° φ_1 = 45. The shape of the groove cutter with the main dimensions is shown in Figure 3. °3.

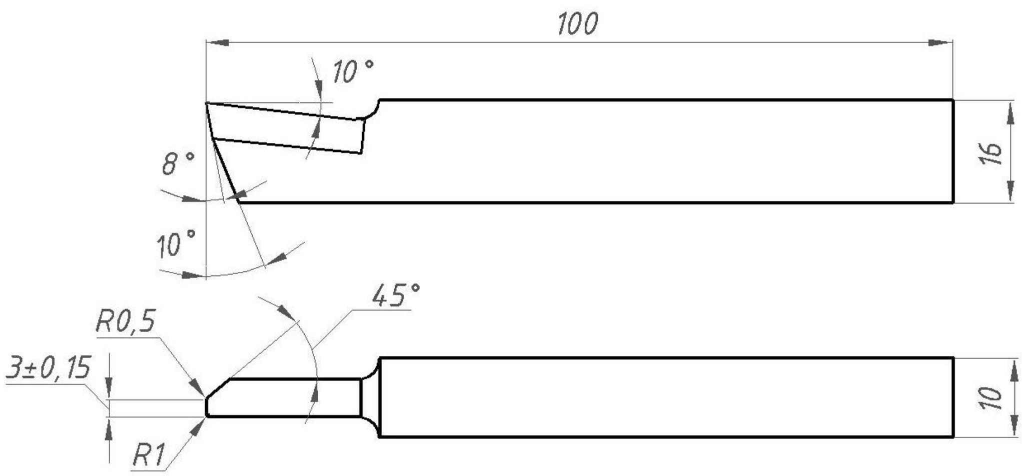


Figure 3. 3 – Constructive parameters of the groove cutter

Cutting force when cutting at the known power and cutting speed

$$P_{z,y,x} = \frac{N \cdot 1020 \cdot 60}{V}, \tag{3. 14}$$

from where the data substitution will be obtained

$$P_{z,y,x} = \frac{3{,}55 \cdot 1020 \cdot 60}{49} = 4433{,}87 \text{ N.}$$

Condition of strength

$$\tau_{zr} = \frac{4433{,}87}{0{,}01 \cdot 0{,}01} = 44338700 \text{ Pa } 44 \text{ MPa} \ll 450 \text{ MPa.}$$

– the condition is met, so the strength of the connection is ensured.

We will check the strength and rigidity of the cutter state.

a) the condition of strength has the following appearance [14]

$$\sigma = \frac{6P_{\max} l_c}{bh^2} \le [\sigma]_B, \qquad (3.15)$$

where $[\sigma]_B$ is the strength limit, $[\sigma]_B$ = 568 MPa (steel 40);

l_c – departure of the incision, l_c = .20 mm

By substiting the data, we obtain

$$\sigma = \frac{6 \cdot 4433{,}87 \cdot 0{,}02}{0{,}01 \cdot 0{,}01^2} = 532064400 \text{ Pa} \approx 532 \text{ MPa} < 568 \text{ MPa}.$$

– the condition is fulfilled, so the strength of the state is ensured.

b) maximum deflection of the state [10]

$$y = \frac{P_{\max} l_c^{\,3}}{3EI} = \frac{4P_{\max} l_c^{\,3}}{Ebh^3}, \qquad (3.16)$$

where E *is* the elasticity module of the cutting state material; $E = 2.15 \cdot 10^5$ MPa.

$$y = \frac{4 \cdot 4433{,}87 \cdot 0{,}000008}{215000000000 \cdot 0{,}00000001} = 0{,}0000066 \text{ m}.$$

– therefore, the rigidity of the incision is sufficient.

4 SAFETY OF LIFE, BASICS OF LABOR PROTECTION

4.1 Protective structures and shelters

Life safety includesmeasures to protect personnel in conditions of natural and technological disasters, accidents, etc. for the development of measures conduct a preliminary study of the factors that can lead to emergencies. density and type of building.

In determining the needs of the number of protective structures at the facility, proceed from the number of the largest working shift, the placement of the bulk of production personnel on the territory of the facility, the conditions for the possible placement of protective structures, their capacity, and other factors.

To calculate the needs of the object in protective structures and their equipment, the following initial data are required: the expected power of the explosion; probable maximum deviation of the center inthe ibuh from the sight point; the average wind speed in the area of the object;wind azimuth; distance of the object from the probable center of the explosion. As well as climatic conditions of the area of location of the object (external air temperature); the total number of workers and employees in the greatest change; scheme of placement of working sites at the facility and dispersion of production personnel on them: possible fire sieveat the facility (expected degree of smoke).

The total bridgeof protective structures should correspond to the number of workers and employees of the object in the largest working shift and be determined by the total amount of seats and lying down.

Places for separate storage facilitiesare separated taking into account theplacement of working areas on the territory of the facility and the number of protected within the radius of collection, as a rule, at least 150 places for one storage facility. and no more, and in new houses under construction and construction – for 5 people. and nothing more.

The room for shelters is built from the calculation that one man had 0.5 m2 of floor space with a two-tiered and 0.4 m2 with a three-tiered placement on the outside. The internal volume of the room should be at least 1,5 m3 per man.

In areas of warm climate, it is allowed to increase the rate of area per man to 0.75 m2. The height of the room should be at least 2,2 m with a two-tier and 2,9 m with a three-tier placement of places from the floor label to the protruding ceiling structures.

In the shelter should be installed two or three-tiered benches for seating. The lower tier is for sitting at the rate of 0,45□0,45 m per person, and the upper tier for lying at the rate of 0,55□1,8 m per person. The height of the first tier is 0.45 m, the bench of the second tier is 1.4 m, the third tier is 2.15 m from the floor.The number of places for lying down is 20% of the storage capacity with a two-tiered placementof l avoks and 30% with a three-tiered one.

The control point (PU) is provided talc at enterprises with the number of workers in the largest change of 60 people. and more. The control point consists of a working communication team, it is separated from the room for covering with a fire-resistant partition with a fire resistance limit of 1 hour. Fromadalong number of workers on the PU should not exceed 10 people.

The norm of the area per worker is . The medical center with an area provided in protective structures with a number will cover 900-1200 people. For every 100 people. and more than 1200 people. the area of the medical center increases by .2 $m^2$9 $m^2$1 m^2

Sanitary posts are provided in the protective structure with an area of every 500 people. at least one post for protective construction. 2 m^2

The vestibule-gateway is provided at one of the entrances to the vault with a capacity of 300 people. At the same time, in the storage of 300-600 people, a single-chamber one is made and in storages more than 600 people are a two-chamber vestibule of the gateway.10 m^2

In the outer and inner walls of the vestibule a-gateway, protective and airtight doors are installed that correspond to the protective properties of the storage.

Filter-ventilating placements are installed in the outer walls of the storage near the entrances or emergency exits. Their dimensions are determined depending on the dimensions of the equipment and the area necessary for its maintenance. In storage facilities with a capacity of up to 150 people, filteringandnon-equipment of the FVK-1 type are allowed to be placed directly in the room for shelters.

The type of protective structures for a particular facility must meet the requirements for ensuring reliable protection of production personnel. The choice of the type of protective structures for the object is reduced to determining the zone of possible destruction in which the object may find itself.

4. 2 Tokeeping safety when working with abrasive wheels

Modern engineering puts high requirements for the quality and cleanliness of the treated surface, which are impossible without the use of abrasive tools and grinding machines for the final processing of metal parts.

When rotating an ordinary circle, centrifugal forces cause tearing stresses. In a highly assertive circle due to its lower volume weight, these forces are significantly reduced, so it is much safer to work with them.

Their balance is important for the safety of life and safety when working with abrasive circles.

It is necessary to store the abrasive tool in accordance with the special requirements.

Before issuing a circle for work, it should be technically checked and inspected. Mechanical inspection of abrasive wheels includes balancing and testing for mechanical strength. The inspection is carried out in order to timely identify external defects (cracks, bumps), internal defects (cracks) by sound, as well as to check the presence and correctness of the marking.

The unbalance of the circle, which is caused by a violation of its geometric shape, is eliminated by static and dynamic balancing. You can always balance the circle with the help of cargo so that the centrifugal forces in it are mutually balanced.

It is necessary to balance each circle in order to create safe working conditions and improve the quality of the treated surface; this is done using balancing devices.

A properly balanced circle when turning should be in equilibrium. Geometrically correct circles are not difficult to balance with fasteners. The balancing process itself consists of two successive stages: checking the static balance of the circle together with the flanges planted on the control frame, by using a special device; elimination of the detected imbalance by moving crackers along the circular groove in one of the fastening flanges.

To ensure the safety of work with circles, it is necessary to test them for strength. The purpose of the tests isto identify possible damage to the circles during their transportation, unpacking, laying, etc. tests are required to conduct all factories-consumers of the abrasive tool, regardless of the presence of a test passport drawn up by the manufacturer. from 150 to 150 mm30 mm 475 mm – 5 min. , diameter and more 500 mm– 7 min. , for high-speed circles with a diameter of 30 to 90 mm – 3 minutes.

For strength circles, youtry on a special stand (machine) rotation without loading at speeds that are 50% higher than the working ones.

The machine is designed to test circles with a diameter of 100 to . The test speed and adjustment of the machine to a given number of revolutions are controlled using a tachometer built into the machine.900 mm

It is allowed to use only reliable and tested fasteners – typical designs of clamping flanges, special cartridges, etc.

CONCLUSIONS

In the qualification work of the bachelor in the general technical and technological part, the analysis of the technical requirements of the details of "hub 180.07.202" and its official purpose. technological process of making hub. It was also carried out the definition of allowances and interoperative dimensions, the choice of technological equipment and cutting tools, as well as the calculation of cutting modes by operations.

As a result of the changes in the technological process, a decrease in artificial calculation time was ensured , as a result of the use of progressive equipment and equipment and combination of transitions, as well as the introduction of a rational method of obtaining a blank into the technological process - casting in a coquel.

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